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CORNISH GEOLOGY.

The Geology of Falmouth and Truro, and of the Mining District of Camborne and Redruth. By J. B. Hill and D. A. MacAlister, with Petrographical Notes by J. S. Flett. Memoirs of the Geological Survey. Pp. x+335; with 65 illustrations and 24 plates. (London: Wyman and Sons, Ltd., 1906.) Price 7s. 6d.

OF the new series one-inch map of England and Wales, few sheets are of greater interest than No. 352 (colour-printed, price 1s. 6d.), which represents that portion of western Cornwall that contains the oldest and richest mines in the county; and the value of the map is greatly enhanced by the admirable explanatory memoir, which contains a description of the older slaty rocks, the granites, elvans, and greenstones of this area, together with particulars of the metalliferous veins. Attention is given to the genesis of the ores, and to their mode of occurrence, to the methods of dressing the tin ore, and to the mineral output. In short, the description is much more detailed than is usual in a Geological Survey sheet explanation.

The original geological survey was carried out by De la Beche, whose results were published in 1839. New editions of the maps were published in 1866, with additional lodes inserted by Sir Warington Smyth. A comparison of the new map with the older one shows that the additions that have been made are of great importance. The area formerly represented as Devonian has been subdivided into Lower Devonian and three subdivisions, based on lithological characters, designated by the terms Portscatho, Falmouth, and Mylor. These three subdivisions, together with the Veryan beds, formerly classed as Lower Silurian, are shown to be Lower Palæozoic. The grits of Gram-pound and Probus, representing the base of the Devonian rocks, are taken as the equivalents of the conglomerate on the Helford River (one-inch map, 359).

The igneous rocks are divided by Mr. Hill into four groups: (1) the greenstones, the oldest, which are epidiorites derived from dolerites and basalts; (2) the granite, the dominant representative, with which the mineral products of the area are intimately associated; (3) the elvans, which represent the dyke phase of granite, and were intruded after its consolidation; and (4) the mica traps, the age of which is uncertain. Chapters are devoted to a description of the contact metamorphism effected by the granite and of the faults. The fractures are the product of the later Carboniferous period, and have a trend of about E.N.E. Many of them occur in the mineral areas, where they form the home of the lodes. They are traversed by a second set of faults, of early Tertiary age, which are known to the miner as cross-courses. The Pliocene deposits receive careful attention, the Polcrebo gravels appearing to represent a patch of the Pliocene deposits which formerly spread over the killas platform of this area, and are represented at St. Erth, St. Agnes, and Crousa Downs in adjacent districts. With the ex-

ception of these gravels, this area affords no evidence of stratified deposits from the Palæozoic period until the Pleistocene, which is represented by the raised beaches underlying the Head, that is probably a product of the Glacial age.

The second part of the work, which is written by Mr. MacAlister, deals with the mining industry of the district. Modern theories of the genesis of ore deposits are applied to the Cornish tin and copper ores, and detailed descriptions of the mines are given, illustrated by more than fifty sketches. Statistics of production since 1845 are set forth in detail, and ten pages are devoted to a description of the tin-ore dressing processes employed in the Camborne area. Products from the various operations have been subjected to microscopic examination, the results showing that grains of cassiterite which are less than the average size of the grains in the concentrates tend to be lost in the tailings of subsequent operations. The dressing operations are elucidated by means of excellent reproductions of photographs.

On the whole, the work is a very creditable production. It forms an excellent introduction to the geology of Cornwall; and it is satisfactory to note that the price at which it is published is not such as to preclude its use by students of economic geology.

MODERN INTRODUCTIONS TO PHYSICAL THEORIES.

- (1) *Elektromagnetische Schwingungen und Wellen.* By Dr. Josef Ritter von Geitler. Pp. viii+154. (Brunswick: Fried. Vieweg und Sohn, 1905.) Price 4.50 marks.
- (2) *Theorie der Elektrizität.* By Dr. A. Foppl and Dr. M. Abraham. Vol. i., pp. xviii+443; vol. ii., pp. x+404. (Leipzig: G. Teubner, 1904 and 1905.)
- (3) *Ueber den gegenwärtigen Stand der Frage nach einer mechanischen Erklärung der elektrischen Erscheinungen.* By Dr. Hans Witte. Pp. xii+232. (Berlin: E. Ebering, 1906.) Price 7.50 marks.
- (4) *Die Fortschritte der kinetischen Gastheorie.* By Dr. G. Jäger. Pp. ix+119. (Brunswick: F. Vieweg und Sohn, 1906.) Price 3.50 marks.
- (5) *An Elementary Treatise on Theoretical Mechanics.* By J. H. Jeans, F.R.S. Pp. viii+364. (Boston and London: Ginn and Co., n.d.) Price 10s. 6d.

A COMPARISON of text-books of the last year or two with those published, say, a quarter of a century ago affords a clear and definite measure of the great changes which have occurred during the interval in our commonly accepted physical theories. All the books now before us reflect these changes in a greater or less degree, but we take Dr. von Geitler's manual as our first example because the author has closely followed the historic order of development in leading his readers from the simple early notions of action at a distance to the modern theories of electrical oscillations and their applications to wireless telegraphy.

Starting with Newton's discovery of the law of gravitation, the reader is led up to Faraday's researches on the electromagnetic field, and he first

learns the dependence of this field on the nature of the medium filling it, and the interdependence of electrostatic and magnetic phenomena. While the author in his preface directs attention to the great difficulty of treating the subject in a popular way, it is noticeable that he has been remarkably successful in overcoming this difficulty, and the liberal use of diagrams illustrating lines of force, as shown both from plotting and by experiment, does much to impart a reality to the discussions. The second section is devoted to Clerk Maxwell's electromagnetic theory of light, and emphasis is rightly laid on the discovery of the coincidence between the " v " of the physicist and the velocity of light. The third section deals with Hertz's classical experiments, culminating in the realisation of electric waves; while the last section is devoted to those further developments which have established the identity in character of electric and optical phenomena and have resulted in wireless telegraphy. This section includes the study of polarisation, dispersion, optical resonance, and the determination of wave-lengths. The author is very clever in the way he keeps mathematical formulæ in the background, and at the same time leaves the reader perfectly conscious of their existence.

Drs. Foppl and Abraham's two volumes deal with the same phenomena treated from the point of view of the advanced student of physics instead of that of the popular reader. For this purpose the historic method of our older books is now quite unsuitable, and we are glad to see its place taken by a more powerful method of treatment. The present writer has clear reminiscences of the difficulties into which the textbooks in use in the 'eighties of last century led the reader. We were taught that quantities of electricity and quantities of magnetism acted on each other according to the law of the inverse square, that the units could be so chosen as to give unit force at unit distance, and that the forces in every case were derivable from a potential. We believed these statements implicitly, and then we were introduced to statements inconsistent with the first under "specific inductive capacity," with the second under "electrostatic and electromagnetic units," and with the third under "electromagnetic induction."

Dr. Abraham's readers start by equipping themselves much better with the analytical methods required for arriving at a clear conception of electromagnetic phenomena. The first section, extending to 122 pages, written by Dr. A. Foppl, deals exclusively with vector analysis and vector fields, and the latter subject is introduced by means of hydrodynamical analogies. It may truly be said that if the study of the dynamics of perfect fluids has not led to many practical applications, it possesses great educational value in affording a simple and intelligible representation of the quantities and equations occurring in electromagnetism. By the time the student has grasped these introductory notions he is able easily to follow the sections on electrostatics and magnetostatics without falling into any misconceptions regarding their limitations, and he can then pass on directly to the study of electromagnetic induc-

tion and electric waves. Especially careful is the author in avoiding the old pitfalls in connection with the "Dimensions of Units." His equations are all written with the three constants, and he then shows how the electrostatic, electromagnetic, and Gauss's systems of units may be obtained by putting two out of these three constants equal to unity. We should, however, have liked to see the dimensions of the units tabulated in terms of force (or perhaps energy), length and time instead of mass, length and time. The formulæ are then much simpler, and better express the fact that electrical phenomena in general manifest themselves to our senses by the *forces* they produce on material bodies, though the existence of these phenomena is independent of the concept of mass as commonly understood.

So much for the first volume, which, as the author points out in his preface to the second volume, covers what may be described as the "first floor" of modern electrical theory. The second floor, which has now been built up as a superstructure on the first, consists of the modern electron theory discussed in this second volume.

The first chapter deals with the definition of an electron and its elementary properties, while the second deals with radiation from electrons. In chapter iii., which deals with the dynamics of a system of electrons, certain assumptions have to be made. In most cases Dr. Abraham follows Lorentz's theory. In the second section, in dealing with ponderable bodies in motion, comparisons are made showing the differences in the results obtained by Lorentz's and Hertz's assumptions.

In a book like the present, dealing with theories about which differences of opinion exist, the list of formulæ collected for reference at the end is particularly useful, as it enables the reader to see at a glance what hypotheses are made. While the book contains an excellent exposition of the electron theory, based on these hypotheses, we only have to turn to the table at the end of Dr. Witte's book to find that there are twelve different conceivable mechanical theories of electric phenomena of which the great majority are classed as recognised theories.

Of these theories, two are theories of action at a distance, and the third is Newton's emission theory, all of which are easily dismissed as insufficient to account for known phenomena. The remaining theories, which Dr. Witte describes as undulation theories, and their classification is a simple matter of permutations and combinations. We have two kinds of energy of the ether, electrostatic and electromagnetic, which have to be potential or kinetic, or partially potential and partially kinetic. These possibilities lead to six different combinations or nine different permutations. The cases where each part of the energies is wholly kinetic or wholly potential lead to three combinations, namely, Mie's group (both energies potential), Lord Kelvin's (one potential and one kinetic), and Hertz's (both energies kinetic). But another totally independent line of classification is also pointed out in the separation of theories of the ether into atomic hypotheses and hypotheses of a con-

tinuous medium, and this line of discussion brings us very close to the electron theory. What the author has really done is to apply the method of exhaustion to mechanical theories of the electromagnetic medium, and he finds that when atomic theories of the ether are taken into account the number of possible hypotheses is very large. Perhaps, as the author points out, no mechanical theory may be found to be capable of explaining satisfactorily all the phenomena of nature. The subject-matter of the present book is certainly only a very small fraction of all that might be written on mechanical theories of the ether, and probably no physicist would regard the arguments as conclusive except so far as they show that certain hypotheses are insufficient to account for the results of experience. But at the same time, if the book does nothing else, it shows that clearer and more definite ideas of existing electromagnetic theories may be obtained by an attempt to exhaust and classify the different possibilities which present themselves.

It is in connection with irreversible phenomena that mechanical theories present the greatest difficulties. As a consequence, the kinetic theory of gases has not received much attention from physicists very recently. But Dr. Jäger points out in the preface to his book that meanwhile an atomic theory of electricity has been built up, bringing us back to the fundamental notions of the kinetic theory of gases. The present book contains a good outline of those applications of the kinetic theory which are most easily understood. Under this heading we include the error law of distribution with special reference to spherical molecules; the virial theorem, a brief account of Boltzmann's minimum theorem without examination of its difficulties, and a discussion of applications to viscosity and other convection phenomena. This book is a very good introduction to place in the hands of the student of physics whose time is very limited, but he must remember that there is a great deal more to be said about the kinetic theory than meets the eye in these pages.

Whether "Theoretical Mechanics" is properly described as a branch of physics or of applied mathematics is a matter of opinion. But the ever-increasing part played by mechanical theories in the study of physical phenomena is sufficient justification for Prof. Jeans's book. It is becoming every year more and more difficult for the science student to keep pace with the demands made on his time by modern developments of physics, and a book which starts with the laws of motion and leads the reader up to Lagrange's equations, all in the compass of a single volume, is certain to prove a great boon to a large class of students. In his preface Prof. Jeans discusses the reasons for carrying the subject so far as the study of generalised coordinates, but in view of the fact that Lagrange's equations are freely used in treatises on electricity—for example, in discussing the effects of mutual and self-induction in electric circuits—no defence of their inclusion in the present volume seems to be needed. In the chapter on motion of rigid bodies we should like to have seen a little

more about "uniplanar" motion. This would enable the student to obtain a much more tangible and definite conception of the meaning of a moment of inertia than is possible when he is rushed on at once to Euler's equations. Moreover, the proof of these equations is unnecessarily cumbersome and difficult for the beginner, and space could easily be saved by simplifying it. The equations of § 250 for moving axes, when generalised for any vector, such as angular momentum, immediately lead to Euler's equations. Instead of doing this, Prof. Jeans gives what is nothing more than an alternative proof of the vector differentiation formulæ, as applied to angular velocity in § 252, and after all this trouble the student has learnt nothing about the fundamental principle involved in both applications.

Returning to the earlier chapters, Prof. Jeans makes an attempt in chapter iii. to prove the parallelogram of forces by the now usually discarded dynamical method. He escapes the fallacies of the old books in connection with the parallelogram of velocities, but is led into the usual *non sequitur* in assuming that the acceleration which the forces produce when acting simultaneously must be compounded of the accelerations which they would produce if acting singly. In connection with his proof of the property that any motion of a rigid body is compounded of a motion of translation and one of rotation, he defines rotation as motion with one point fixed; the subsequent paragraph, headed "Axis of Rotation," is so extraordinary that it is best reproduced here in full. It runs as follows:—

"In a motion of rotation, let P be the point which remains fixed. Take any plane A through P and let B be the position of the plane A after the rotation has occurred. These two planes both pass through P, and must therefore intersect in some line PQ passing through P. This line is called the *axis of rotation*. The rotation can be imagined as a turning about an imaginary pivot running along the axis of rotation."

The absurdity of this statement is evident if we suppose that the chosen plane A does not contain the axis of rotation.

The book is freely illustrated by examples. Many of these are very useful, but others are calculated to inculcate very extraordinary ideas in the mind of the reader. For example, on p. 68 we have an impossible figure of a nut-cracker, neither the nut nor the cracker being in equilibrium. The ladder in the next example is free from this objection, but it contains a superfluity of trigonometry which is hardly justified by the preface. The question can be solved by geometry with half the work. On p. 194 is given a construction for placing a chute in such a position that the time of sliding from a ship's side on to a pier may be as short as possible. If any reader were to put the matter to a practical test, he would certainly not get the same result, even if he got the objects to slide at all. The correct construction is obtained by placing the chute along a chord of a certain circle touching the ship's side, but the tangent to this circle at the point where it meets the pier

should be inclined at the angle of friction to the horizon instead of being horizontal.

Suppose next that the inquiring reader wishes to put the examples on the motion of pulleys of given mass on pp. 202, 203 to a practical test. He goes to a scientific instrument maker, and orders some expensive pulleys. However well he oils their bearings to make them smooth, it is pretty certain they will never move with the accelerations given by Prof. Jeans's formulæ. The tensions of a string may be equal on both sides of a pulley so long as that pulley remains at rest, but so soon as it begins to rotate differences of tension will be set up, and no amount of lubrication applied to the bearings will affect the result. Of course, if the inertia of the pulley is small, the tension differences will also be small, but the masses of the pulleys are "given" in the questions, and the proper lesson to be learnt is that a solution of the problems which does not take account of rotational as well as translational inertia is incorrect.

There are several good features, however, which well deserve mention. Among these are the treatment of strings, including the early references to Hooke's law, the example on p. 53, with its neat geometrical solution, the example on p. 360, in which accelerations in polar coordinates are deduced from Lagrange's equations, and finally the omission of all references to poundals, slugs, and other abominations of the same nature. It is a pity that some of the examples involve the usual tedious and uninteresting drudgery in the form of multiplication or division by 2240 or 5280 or 1728 or 33,000, or another of the same series of objectionable numbers. We do not blame Prof. Jeans for following the common practice in this respect, as most of us find ourselves forced to do the same, but surely the time has come when examples involving the metric system may figure more freely than they do in treatises on theoretical mechanics, especially when those treatises are particularly adapted for students of physics. G. H. B.

THEORETICAL ELECTROCHEMISTRY.

The Electrolytic Dissociation Theory. By Prof. R. Abegg; translated by Dr. Carl L. von Ende. Pp. ix+180. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd.) Price 5s. 6d. net.

Electrochemistry. Part I., Theoretical Electrochemistry and its Physico-chemical Foundations. By Dr. Heinrich Danneel; translated by Dr. Edmund S. Merriam. Pp. vii+181. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd.) Price 5s. 6d. net.

THE advent of the translation of these two little books into English shows that the subject of electrochemistry, or rather, we should say, physical chemistry, with an electrochemical bias is coming more and more to the front. But while we have had of late a large number of books upon the theoretical side of the subject, there is not very much

literature dealing with the practice of electrochemistry and its applications to industrial problems.

Prof. Abegg's book is a translation of the author's "Die Theorie der elektrolytischen Dissociation," which appeared in 1903 in the "Sammlung chemischer und chemisch-technischer Vorträge." Prof. Abegg starts off in an elementary manner, and explains the dissociation theory so that the beginner may understand the subject. On several occasions he uses the term osmotic pressure, but throughout the book he does not explain what osmotic pressure is or how it is measured. Although the commencement of the book is quite simple, it is not long before Prof. Abegg revels in mathematics, which, combined with the slavish style of the translation, makes the reading rather uninteresting. The section upon equilibria among several electrolytes is very long, and includes subsections upon hydrolysis, avidity or affinity of acids and bases for each other. The style of the book may perhaps be shown by the following passage:—

"Since in the case of equal concentration the ionic concentrations of pure (unmixed) acids are to each other as the roots of their dissociation constants, we may with Arrhenius also express this equation thus, that both acids divide themselves between the base in the same ratio as their degrees of dissociation would be, if each were present alone in the volume considered."

A section is also devoted to "non-aqueous solutions," and in it the author explains some of the difficulties which occur when one tries to bring the behaviour of solvent and solute into line with a similar substance dissolved in water; for example, the complications arising by the phenomena of the association of the non-ionised portion of the electrolyte. The book is a useful review of the ionic theory written entirely with the view of supporting the theory.

Dr. Danneel's book, although it explains the ionic theory in considerable detail, is an exposition of general theoretical electrochemistry. The book begins with an explanation of the terms work, current, and voltage. The gas laws lead up to osmotic pressure, which is fully and lucidly presented. The theory of electrolytic dissociation and conductivity brings us up to p. 114. The average student who is called upon to study the ionic theory will obtain, we venture to think, a better grip of the subject by a study of Danneel's book than from that of Abegg. The latter book treats the subject more fully, but Danneel's style is more interesting, and he leaves none of the salient facts out. Chapter v. treats of electromotive force and the galvanic current, and chapter vi. of polarisation and electrolysis. The last chapter, which is very short, treats of the electron theory. We find it here stated that "The electron acts chemically like an element. It combines with other elements to form saturated compounds, which are the ions"; thus



It would have been of special interest had Dr. Danneel enlarged upon this subject; he has, however, just given enough to make it suggestive.